Influence of Moisture and Temperature on Soil Micronutrient Supply, Uptake and Biomass Yield of Wheat, Pea, and Canola

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INTRODUCTION

- Moisture and temperature stresses influence crop growth, productivity and nutrient demand (Hasanuzzaman et al., 2013).
- Environmental conditions can affect the ability of the soil to supply micronutrient to plant roots (Alloway, 2008, 2009).
- Dry and cold soil conditions are anticipated to lead to reduced availability and supply to roots, and also negatively affect root growth and decrease overall demand.

OBJECTIVE

✓ To assess Cu, Zn, and B mobility, bioavailability, and micronutrient fertilization growth responses of wheat, pea, and canola grown under sub-optimal conditions of moisture and temperature.

MATERIALS AND METHODS

✓A growth chamber study was conducted using 2 kg air-dry surface field soil (Brown Chernozem, Kettlehut association) in pots to grow wheat, pea, and canola for six weeks.

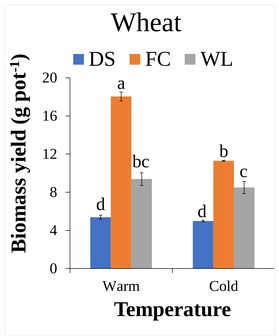
✓Copper and Zn were applied at the rate of 5 kg Cu, Zn ha^{-1} using sulfate form for wheat and pea fertilization, respectively. Boric acid fertilizer was applied for canola at the rate of 1 kg B ha^{-1}.

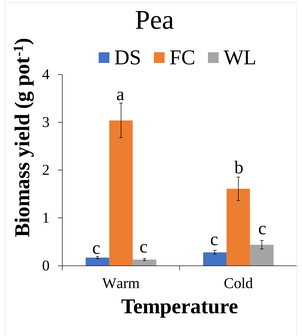
✓The experimental treatments consisted of three soil moisture and two temperature environments imposed at early growth stages representing the cool-wet (e.g. early spring) or warm-dry (e.g. late spring) seasonal extremes that may be encountered post-seeding in Western Canada.

✓ The three soil moisture treatments were drought stress (DS) set as 50% of field capacity, field capacity (FC), and waterlogged (WL) conditions with soil submerged and all pore space filled with water. The plants were then grown in two different growth chambers with cold (5 ^{o}C continuously) and warm (23 ^{o}C and 18 ^{o}C for day and night, respectively) temperature conditions.

✓ Crops were harvested after six weeks of treatment and dry matter biomass yields are reported.

RESULTS AND DISCUSSION





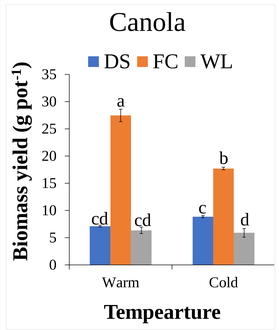


Fig. 1. Biomass yield of wheat, pea, and canola grown under three different moisture [DS = Drought stress (50% of field capacity), FC = Field Capacity, and WL = Waterlogged] and two temperature regimes [warm: 23 ^{o}C and 18 ^{o}C for day and night, respectively and cold: 5 ^{o}C] under controlled environment conditions. For a crop, treatment columns followed by the same letter are not significantly different ($p > 0.05$). Error bar represents standard error of mean.

Table. 1. Effect of temperature and soil moisture on Cu, Zn, and B uptake by wheat, pea, and canola, respectively.

Treatments		Cu (Wheat)	Zn (Pea)	B (Canola)
Temp.	Moist.	----------mg pot^{-1}----------		
Warm	**DS**	31.7b	5.78c	286b
	FC	72.8a	172a	675a
	WL	41.4b	5.62c	147c
Cold	**DS**	31.7b	12.7c	290b
	FC	63.5a	76.6b	559a
	WL	33.7b	19.4c	211bc
p values		<.0001	<.0001	<.0001
SEM		2.94	9.75	30.5

Table. 2. Extractable soil Cu, Zn, and B in wheat, pea, and canola post-harvest after six weeks of growth under different temperature and moisture regimes

Treatments		Cu (Wheat)	Zn (Pea)	B (Canola)
Temp.	Moist.	----------mg kg^{-1}----------		
Warm	***DS***	1.97a	4.22a	2.42a
	FC	1.97a	3.82a	2.38a
	WL	2.20a	3.37a	2.72a
Cold	***DS***	2.07a	4.93a	2.74a
	FC	2.23a	3.22a	2.73a
	WL	2.06a	3.54a	2.71a
p values		0.953	0.120	0.130
SEM		0.226	0.437	0.159

Table. 3. Supply rate (measured by in situ burials of PRS™-probes) of Cu, Zn, and B over a one week time period in soils with wheat, pea, and canola grown under different temperature and soil moisture conditions. Measurements were made at 1, 3 and 5 weeks after seeding.

Treatments		Cu (Wheat)			Zn (Pea)			B (Canola)		
Temp.	Moist.	W_1	W_3	W_5	W_1	W_3	W_5	W_1	W_3	W_5
		----------µg/cm^2/week----------								
Warm	***DS***	0.40a	0.26bc	0.22a	0.23a	0.10b	0.16ab	0.04a	0.03a	0.03a
	FC	0.38a	0.56a	0.46a	0.45a	0.35a	0.23ab	0.04a	0.03a	0.02a
	WL	0.34a	0.41abc	0.37a	0.24a	0.29ab	0.31a	0.04a	0.04a	0.02a
Cold	***DS***	0.42a	0.20c	0.25a	0.20a	0.18ab	0.15b	0.03a	0.03a	0.03a
	FC	0.51a	0.63a	0.40a	0.32a	0.29ab	0.21ab	0.04a	0.04a	0.04a
	WL	0.39a	0.51ab	0.33a	0.39a	0.31ab	0.26ab	0.04a	0.02a	0.03a
p values		0.058	0.0003	0.315	0.124	0.036	0.037	0.366	0.202	0.061
SEM		0.036	0.059	0.080	0.069	0.053	0.036	0.002	0.007	0.004

Table. 4. Concentrations of Cu, Zn, and B in sequentially extracted fractions from post-harvest soils in which wheat (Cu), pea (Zn), and canola (B) were grown under different temperature and moisture conditions. Different fractions are F_1: soil solution-carbonate-exchangeable fraction (Cu and Zn) or specifically adsorbed fraction (B); F_2: oxyhydroxide fraction; F_3: organic-bound fraction.

Treatments		Cu (Wheat)			Zn (Pea)			B (Canola)		
Temp.	Moist.	F_1	F_2	F_3	F_1	F_2	F_3	F_1	F_2	F_3
		---------- mg kg^{-1} soil ----------								
Warm	**DS**	1.23a	1.50a	3.55a	2.12a	5.97a	4.71a	1.36a	0.39a	2.88a
	FC	1.27a	1.53a	3.63a	2.30a	5.62a	4.79a	1.20a	0.29a	2.90a
	WL	1.30a	1.48a	3.41a	1.97a	5.33a	4.95a	1.41a	0.21a	2.98a
Cold	**DS**	1.29a	1.32a	3.49a	2.26a	5.70a	4.93a	1.45a	0.33a	3.06a
	FC	1.20a	1.39a	3.73a	2.35a	5.38a	5.05a	1.17a	0.13a	2.71a
	WL	1.30a	1.27a	3.97a	2.07a	5.51a	5.09a	1.19a	0.19a	2.97a
p values		0.991	0.929	0.368	0.966	0.743	0.829	0.453	0.083	0.966
SEM		0.134	0.208	0.186	0.350	0.318	0.225	0.125	0.062	0.280

- The highest biomass yields were obtained under warm temperature and optimum (field capacity) soil moisture conditions for all crops (Fig. 1). Crops grown under drought (50% field capacity) or excessive soil moisture (saturated) conditions had greatly reduced biomass production. Cold temperatures had greatest negative impact on plant biomass when grown under optimal moisture conditions.
- The uptake of Cu, Zn, and B by wheat, pea and canola (Table 1) followed the patterns in biomass production, with moisture stress having much greater impact than temperature, with only Zn uptake significantly reduced by cold temperatures.
- Moisture and temperature treatments did not significantly affect extractable Cu, Zn, and B in the post-harvest soils (Table 2). However, the mobility of Cu and Zn in the soil as reflected in the supply to PRS probes was significantly reduced with droughty soil conditions, especially during weeks 2 and 3 (Table 3). This may be explained by a more tortuous diffusion path under dry soil conditions.
- Moisture and temperature had relatively little impact on the concentrations and distribution of micronutrient among labile and stable soil chemical fractions (Table 4).

CONCLUSIONS

- Dry or excessively wet soil conditions results in reduced early season biomass production and micronutrient uptake by wheat, pea and canola.
- Micronutrient fertilization practices may consider the effect of dry soil on limiting the ability of micronutrient metals to move to root surfaces, such as closer placement to roots or foliar spray.

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